



7. MPI-P – CPI Joint Seminar
18. & 19.4.2007, IMTEK - Uni Freiburg

Program & Abstracts

Program

Wednesday, 18.4.2007

- 10:30 arrival, welcome hugs
Chair: Jürgen Rühle
- 10:45 Jürgen Rühle
IMTEK and CPI at a detailed glance
- 11:30 Meike Moschallski
Tuning polymer protein chips
- 11:50 Jakub Dostalek
Long range surface plasmons for observation of biomolecular binding events at metal surfaces
- 12:10 Kerstin Schuh
Baking Polymers: Thermal crosslinker to generate surface attached polymer networks
- 12:30 Lunch
- 13:30 **Poster Session I**
Chair: NN
- 14:30 Hatice Duran
NCA Polymerization In Confined Geometries
- 14:50 Dr. Thomas Brandstetter
A novel 3D-Biochip platform for HPV diagnosis
- 15:10 Maria Gianneli
Local and Global Dynamics of Hydrogels as Studied by Fluorescence Correlation Spectroscopy
- 15:30 Hyun-Kwan Yang
PEL brushes for PEL multilayers
- 15:50 Coffee Break
Chair: NN
- 16:30 K.H. Aaron Lau
Self-segregated adsorption of proteins on self-assembled block-copolymer nanopatterns
- 16:50 Gerhard Baaken
A 42-type planar patch clamp chip
- 17:10 Chuan-Liang Feng
Quantum-Dot/Dendrimer Based Functional Nanotubes for Sensitive Studies of DNA Hybridization
- 17:30 Anye N. Chifen
Plasma polymerized biofunctional multilayers based on a SiO₂-like adhesion film
- 17:50 Departure to hotel
- 19:00 Dinner & Special Event: World Savings Seminar feat. WK

Thursday 19.4.2007

- Chair: NN*
- 9:00 Julien Couet
Pimp my nanotubes
- 9:20 Piotr Jakubowicz
Synthesis of Porous Hydrogel Networks
- 9:40 Julia Viertel
The Power of Surface Forces: Guiding Liquids in Microchannels
- 10:00 Andreas Unger
Characterization of the swelling behaviour of hydrogels with evanescent Ellipsometry and neural nets
- 10:20 Anke Wörz
Tailormade surfaces for the guidance of neuronal cells
- 10:40 Coffee Break
- 11:10 Tour de IMTEK
- 12:10 Lunch
- 13:10 Poster Session II
Chair: NN
- 14:00 Mathieu Jung
Polymerisable lipids for patterned tethered bilayer membranes
- 14:20 Christian Schuh
Walking a fine line - generation of nanogradient polymer brushes
- 14:40 Jens Weinberg
Biofunctionalization of aminogroup-presenting plasma-polymerized thin films by covalent attachment of antibodies
- 15:00 Christian Schlemmer
MPFPF – Nanoparticles do the waltz
- 15:20 Coffee Break
Chair: NN
- 16:00 Robert F. Roskamp
Functional Smart Hydrogels
- 16:20 Christian Dorrer
Ultrahydrophobic surfaces with posts and polymers
- 16:40 Matthias Junk
Structure and Structuring of Thermoreversible Hydrogelsystems
- afterwards: good-bye tears (tissues provided) and off you are

Posters

MPI-P posters

Annette Brunsen

Responsive dextrane-based hydrogels for application in biosensors

Christian Ohm

Hydrogels as a water reservoir for tethered bilayer lipid membranes

Hatice Duran

Synthesis of Polypeptide nanotubes for biosensor applications

Monica Mir

Oligonucleotide biofunctionalisation of smart hydrogels observed by surface plasmon fluorescence spectroscopy

Omar Azzaroni

Doing Chemistry in Thin Polymer Films

CPI posters

Julien Couet

Synthesis of polymer-wrapped peptide nanotubes

Yuri Egorov

Crosslinked peptide nanotubes

Sidar Loschonsky

Controlled polymerization from initiator-modified peptides

Sönke Petersen

Peptide polymers on microstructured surfaces

Kimberley Simancas

Swelling behavior of surface-attached strong polyelectrolyte - surfactant complexes

Ding-Ding He

Fishing in a Beaker: Vitamin D capturing with hydrogels

Christine Schlipf & Kerstin Schuh

Novel Polyelectrolyte Gels for Biofuel Cells

Nicolas Schorr

Towards polymer based magnetic microstructures

G.K. Raghuraman

A novel approach to attach polymer monolayers and its use for premolded packages

Thomas Brefka

Microarray read-out technology using attenuated total internal reflection

Gerhard Baaken

A 42-type planar patch clamp chip

Meike Moschallski

Antibody Microarrays Based on Microstructured Surface-Attached Hydrogels

Abstracts - Talks

Meike Moschallski, Oswald Prucker, Jürgen Rühle

Tuning Polymer Protein Chips

Proteins are immobilized in surface-attached hydrogel microstructures on polymer substrates by simple benzophenone photochemistry. The fluorescence signal of immunoassays on these polymer protein chips can be tuned by composition and size of the microstructures. The concentration of analyte proteins in solution can be determined by measuring the reaction kinetics on-chip.

Jakub Dostalek, Wolfgang Knoll

Long range surface plasmons for observation of biomolecular binding events at metal surfaces

A long range surface plasmon (LRSP) is an electromagnetic wave propagating along a thin metal film with an order of magnitude lower damping than conventional surface plasmon (SP) waves. Thus, the excitation of LRSP is associated with a narrower resonance and it provides larger enhancement of intensity of the electromagnetic field. In surface plasmon resonance (SPR) biosensors, these features allow a more precise observation of binding of biomolecules in the proximity to the metal surface by using the (label-free) measurement of refractive index (RI) variations as well as by SP enhanced fluorescence spectroscopy.

We investigated LRSPs excited on a layer structure consisting of a fluoropolymer buffer layer, a thin gold film, and an aqueous sample. By implementing such structure in an SPR sensor, we achieved a 2.4 and 4.4 fold improvement of the resolution in the label-free and fluorescence-based detection, respectively, of binding of biomolecules in the close proximity to the surface. Moreover, we demonstrate that the sensor resolution can be improved by a factor of 14 and 12 for the label-free and fluorescence-based detection, respectively, if the biomolecular binding events occur within the whole evanescent field of LRSP.

In addition, we will illustrate our current research in LRSP-based sensors aimed at the development of the electro-optical modulation of SPR, diffraction out-coupling of LRSPs and on the combining of LRSP-based sensors with three-dimensional hydrogel matrices for the observation of biomolecular binding events.

Kerstin Schuh Oswald Prucker, Jürgen Rühle

Baking Polymers: Thermal crosslinker to generate surface attached polymer networks

The generation and characterization of surface attached polymer networks with benzophenone-groups has been done in our group intensively. However, for some applications photochemistry cannot be used and new ways of crosslinking are necessary. Herein, we report a new way to design networks with a thermal crosslinking process. Therefore, polymers containing azide-groups were developed, which crosslink with an CH-bond-insertion and the loss of nitrogen during heating.

Hatice Duran, King Hang Aaron Lau, Ulrich Jonas and Wolfgang Knoll

NCA Polymerization in confined geometries

N-carboxy anhydride (NCA) monomer molecules were condensed on the pore walls of an initiator-coated nanoporous alumina template, leading to polypeptide (poly(γ -benzyl-L-glutamate), PBLG) film formation. While the NCA monomer was polymerized within the pores, the wall thickness of the resulting polypeptide was tuned by changing the polymerization time. This polypeptide-coated alumina membrane have been used as planar optical waveguide to monitor the changes in the refractive index of the composite membrane

through specific binding of a bio-analyte. We monitored for the first time the in-situ formation of an initiator layer (3-Aminopropyltriethoxysilane, APTE) and polypeptide growth inside the pores of an alumina membrane via optical wave-guide spectroscopy. Attachment of initiator molecule effectively changed the dielectric constants of the interfaces, resulting in detectable shifts of the waveguide modes. We demonstrated that unmodified nanoporous alumina waveguide sensor having a 10 times higher sensitivity than surface plasmon spectroscopy (SPR).

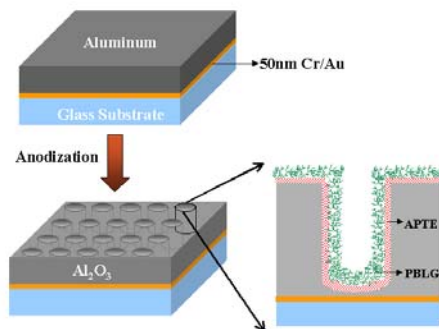


Figure 1 – Schematic representation of Polypeptide films formed inside pore walls of a thin anodic alumina membrane.

1. Duran, H.; Jonas, U.; Steinhart, M. and Knoll, W. *Polymeric Materials: Science & Engineering Preprints*, 2006, 94, 291-292.
2. Duran, H.; Lau, K. H. A., Jonas, U. and Knoll, W. *Polymeric Materials: Science & Engineering Preprints*, 2006, 95, 345-347.
3. Duran, H., Lau, K. H. A., Lübbert, A., Jonas, U., Steinhart, M. and Knoll, W. in *Polymers for Biomedical Applications*, Anil Mahapatro, Ed.; ACS Symposium Book Series, Oxford University Press, In press.
4. Lau, K. H. A; Tan, L- S.; Tamada, K.; Sander, M. S. and Knoll, W. *J. Phys. Chem. B*. 2004, 108, 10812.

Thomas Brandstetter, Katrin Wagner, Thomas Brefka and Jürgen Rühle
A novel 3D-Biochip platform for HPV diagnosis

One of the key problems in the development of a DNA chip for a given analytical problem is the determination of suitable chip parameters such as the DNA probe sequences with best binding affinity and optimized hybridization conditions mentioning buffer concentrations and temperature for robustness and increased sensitivity. These features are by no means exhaustive, because thousands of experiments and test chips are leading to often unacceptable development times and costs. Additionally, diagnostic tools have to be robust, cheap, easy to handle and may be reusable.

Therefore, we take care of these efforts in the biochip business by presenting a biochip analysis platform technique, which consists of three key features:

- a) A total internal reflectance fluorescence (TIRF) read-out system, in which the fluorescence is excited through the chip itself, which acts as a waveguide.
- b) The second key feature of this system is the chip itself. We have developed a polymer chip made from PMMA onto which the probes are printed together with a photocrosslinkable polymer. Upon illumination the polymer forms a three dimensional hydrogel, that acts as a carrier for the probes. This "skyscraper" approach allows for the deposition of a higher probe concentration per surface area leading to an enhanced chip sensitivity and selectivity.

c) Third, we developed an easy to handle procedure for using these biochips.

For featuring such progress in robustness and sensitivity we have developed a HPV-DNA chip for defining the HPV type.

M.Gianneli, P. Beines, R. Roskamp, K.Kaloian, G.Fytas, W.Knoll
Local and Global Dynamics of Hydrogels as Studied by Fluorescence Correlation Spectroscopy

Hydrogels are three-dimensional cross-linked networks that incorporate a significant volume fraction of water. Cross-linked poly(N-isopropylacrylamide) (PNIPAAm) is a well-known representative of those polymer networks, which show lower critical solution temperature (LCST) behavior. Bulk behavior of these polymers is widely studied and they show an isotropic swelling. However, thin hydrogel layers grafted on a substrate display quite a different behavior.

Here, we demonstrate how fluorescence correlation spectroscopy (FCS) can quantitatively address the length scale dependent dynamics of supported PNIPAAm network films through the diffusion of tagged particles. The FCS technique is based on detecting the fluctuations of the fluorescent light intensity in a small observation volume, usually formed by the focus of a confocal microscope. Due to the very small detection volume (~fL) and its high sensitivity, FCS is perfectly suited to study the tracer diffusion in thin, supported gels.

In this work, the focus is on physical PNIPAAm networks in ethanol with controlled average mesh size as inferred by photon correlation spectroscopy (PCS). Using FCS and different size tracer diffusants, both the local and global transient polymer network dynamics can be probed. This tracer diffusion can then be utilized to provide structural information of grafted chemically cross-linked PNIPAAm films of different cross-linking density swollen also in ethanol.

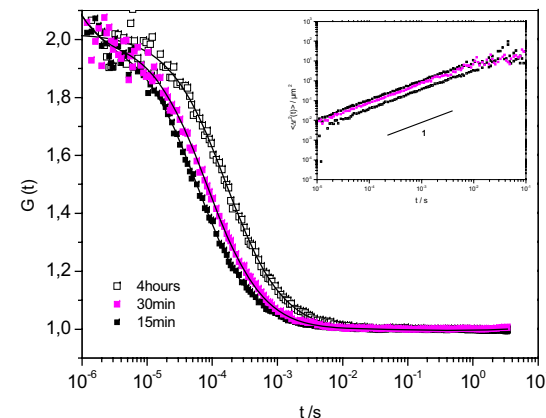


Figure: FCS measurements on PNIPAAm gels in ethanol for different cross-linking times (fluorescent dye : Rh6G)

Hyun-Kwan Yang, Oswald Prucker, Jürgen Rühle
PEL brushes for PEL multilayers

In this work, we want to explore the influence of PEL brushes on the LBL process as a function of chemical nature of brush (weak or strong PEL), brush thickness, graft density of brush and parameters applied during LBL (pH, ionic strength)

K.H. Aaron Lau, Dongha Kim, Wolfgang Knoll
Self-segregated adsorption of proteins on self-assembled block-copolymer nanopatterns

Many proteins physisorb indiscriminately when presented with either polystyrene or PMMA surfaces. Interestingly, it has been reported that certain proteins will preferentially adsorb onto PS nanodomains when presented with a polystyrene-block-poly(methyl methacrylate) (PS-b-PMMA) surface with alternating PS and PMMA nanodomains. We have prepared thin films of PS-b-PMMA with domain sizes ranging from 10-1000 nm. Using goat-IgG as example, we show that the preferential adsorption onto PS surfaces is absolute—the proteins will not adsorb onto PMMA even when all PS sites are occupied. Moreover, adsorption kinetics show that the mixed PS/PMMA block copolymer surfaces are highly efficient for protein adsorption when compared with pure PS and pure PMMA surfaces. To explore the possible mechanisms behind the phenomenon, we also investigated the adsorption behavior over a range of length scales from 10-1000 nm.

Gerhard Baaken, Markus Sondermann, Oswald Prucker, Jan Behrends, Jürgen Rühle
A 42-type planar patch clamp chip

The investigation of transport processes through cell membranes is of interest academically and also for research areas such as drug development. The "golden standard" is a patch-clamping experiment. Traditionally, a part of a cell membrane containing a channel is sucked into a glass pipette and the ionic current through this channel is measured. The same experiments can also be done, using lipid bilayers e.g. as: Black Lipid Membranes (BLMs), spanned over a hole in a glass slide or a teflon foil or as tethered membranes on substrates. The Aim of our research in this field is to combine the two existing models within a micro-array-approach, using microsystem-technology to generate a platform for rapid and reliable high throughput screening of membrane channels.

Chuan-Liang Feng, Xinhua Zhong, Martin Steinhart, Jean-Pierre Majoral, Wolfgang Knoll
Quantum-Dot/Dendrimer Based Functional Nanotubes for Sensitive Studies of DNA Hybridization

A highly sensitive method for detecting oligonucleotide targets has been developed in quantum dot (QD) functionalized nanotubes (NTs) that contain a cascade energy band gap architecture. The design of the functionalized NTs with multi-functionalities and their efficient assembly with different types of QDs was achieved by layer-by-layer (LBL) approach. This allowed for the formation of fluorescence resonance energy transfer (FRET) structures in the NTs resulting in an enhanced fluorescent emission from dye labeled oligonucleotide targets captured by probe DNA through hybridisation. It is demonstrating that this approach results in a significantly enhance of detection of dye labeled oligonucleotide target analysis. It is quite promising to further increase the sensitivity and detecting limits by tuning the QD emission, adding more types of QDs, or adjusting the distance between the QDs and the chromophores.

Anye N. Chifen, Renate Förch
Plasma polymerized biofunctional multilayers based on a SiO₂-like adhesion film

This presentation will describe a method by which intact vesicles can be chemically attached to hydrolyzed maleic anhydride films covalently bound to plasma polymerized SiO₂ on Au substrates. Surface Plasmon Field-Enhanced Fluorescence Spectroscopy (SPFS) combined with Surface Plasmon Resonance spectroscopy (SPR) was used to monitor the activation of plasma deposited maleic anhydride (pp-MA) film with EDC / NHS and the subsequent coupling of lipid vesicles. The vesicles were formed from a mixture of phosphatidylcholine and phosphatidylethanolamine lipids, with a water-soluble fluorophore encapsulated within. Vesicle attachment was measured in real time on plasma films formed under different pulse conditions (plasma duty cycle). Optimum vesicle attachment was observed on the pp-MA films containing the highest density of maleic anhydride groups. Phospholipase A2 was used to lyse the surface-bound vesicles and to release the encapsulated fluorophore.

Julien Couet, Markus Biesalski
Pimp my Nanotubes

Highly dense grafting of polymer chains was carried out from supramolecular tubular structures. Investigation was performed to understand the morphology changes induced by "excluded volume" repulsion. Polymer-peptide nanotubes were used as template for designing metal nanowire.

Piotr Jakubowicz
Synthesis of Porous Hydrogel Networks

Hydrogel precursors containing hydrophilic backbone elements, benzophenone methacrylate crosslinker and functional groups were synthesized by free radical polymerization. The swelling of the gels was examined by SPR/OWS. Different porogens were incorporated into the hydrogel in order to enlarge the hydrogel surface.

Julia Viertel, Oswald Prucker, Jürgen Rühle
The Power of Surface Forces: Guiding Liquids in Microchannels

Shrinking the size of equipment of a chemical laboratory onto micro-sized chips is a huge area of research. One important process is for example the temporary mixing of two immiscible liquids for liquid-liquid extraction. As there is only laminar flow in microchannels, turbulences have to be generated artificially. In our approach the generation of turbulences only by means of surface forces is studied. By spatial variations of the surface chemistry along the channel two immiscible liquids can be forced to cross each other.

Andreas Unger, Cathrin Corthen, Bernhard Menges
Characterization of the swelling behaviour of hydrogels with evanescent Ellipsometry and neural nets

The swelling behaviour of thin photocrosslinked N-isopropylacrylamide (NIPAAm) films and N-isopropylacrylamide/2-vinylpyridine (P2VP) blockcopolymerfilms was investigated. For this investigation, variable-angle-ellipsometry (VAE) in prism-configuration was used. Swelling ratios as well as transition temperatures of these polymer films were measured. Also inhomogeneities in the films were investigated. For evaluating the ellipsometric spectra, artificial neural nets were employed. These trained artificial neural nets are found to be a very fast and reliable method of interpreting ellipsometric spectra.

Anke Wörz, Oswald Prucker, Ulrich Egert, Jürgen Rühle

Tailormade surfaces for the guidance of neuronal cells

Spatial control over cell adhesion on material surfaces has become a subject of biomedical and biotechnological applications. The definition of distinct cellular adhesion sites may be used, for example, to tether cells to selected areas of a biosensor for pharmaceutical testing. In the field of Neurophysiology the control of the adhesion of neuronal cells on the sensitive spots of an extracellular recording device combined with a directed neuronal outgrowth on pathways, along which these neurons can interconnect, allows highly defined experiments on cellular interactions, network behaviour, and neurocomputing and may provide a tool for the creation of neurological implants and their integration into the host tissue. The key-issue for the successful integration of neuronal cells into defined areas of artificial materials is perhaps the control of the physicochemical properties of surfaces. This poster will report on strategies how to tailor the surface-chemistry by using a simple photochemical approach, which allows the covalent attachment of polymers to surfaces containing self assembled monolayers of photoactive benzophenone moieties. Using this process a variety of different polymer coatings can be prepared both, surface-attached polymer films that support the adhesion and outgrowth of living cells as well as stable surface coatings that do not allow the attachment of living cells. Micro-structuring of the polymer layers can be carried out by selectively photolinking the polymer film, by using a simple ablation technique, which selectively removes the polymer, by using μ -contact printing techniques, or by a combination of these techniques.

Mathieu Jung, Wolfgang Knoll, Ingo Köper

Polymerisable lipids for patterned tethered bilayer membranes

Various model membranes have been developed in the past to study the physical and physiological properties of biological membranes.

Amongst them, covalently bound (tethered) lipid bilayers on solid substrates became of practical and scientific interest. The decisive advantage is that they provide at the same time a protective support to the fragile membrane accessible by various surface analytical tools and the possibility to build a lamellar and geometrically well-defined lipid platform.

We have developed a modular system, which is suitable for gold or oxide surfaces. These systems serve as a quasi-neutral environment for the study of membrane proteins, being functionally incorporated into a tethered lipid bilayer. Functionality could be shown using electrochemical methods.

Now that we achieved the construction of a viable support for functional protein incorporation, we aim to control the membrane formation according to a chip-like patterned substrate. This step would permit the creation of protein arrays over different sensing areas. The basic idea is to selectively polymerise the membrane with small fluid areas where the proteins can incorporate.

We synthesised lipopolymers, bearing polymerisable sorbyl or diacetylene groups in the hydrophobic part of the lipid, offering at the same time the possibility to be anchored to the substrate. The cross-linking of these new molecules in the plane of the substrate is light induced with a ultra-violet lamp. The possibility to illuminate through a mask makes this procedure very versatile. We could follow the polymerisation process observing the resistance increase of the membrane with electrochemical impedance spectroscopy. Moreover the film properties were also investigated with surface plasmon spectroscopy in the waveguide mode.

Christian Schuh, Oswald Prucker, Svetlana Santer, Jürgen Rühle

Walking a fine line - generation of nanogradient polymer brushes

Brushes exhibiting gradients in grafting density or molecular weight can be synthesized by different approaches.^{1,2} Depending on the technique, gradients on a cm or mm scale are accessible. Santer et al. have presented a new way to move nanoparticles simultaneously by

a phaseseparated polymersubstrate.^{3,4} To give this random motion a preferential direction, gradients on the scale of the adsorbed particles are necessary. We report on the generation of polymer brushes with "fine lines" in the μ m- down to the nm- scale using interference lithography. In a second approach light responsive brushes are synthesized and reversibly patterned resulting in height gradients.

- (1) Tomlinson, M. R.; Genzer, J. Chem. Commun. 2003, 1350.
- (2) Harris, B. P.; Metters, A. T. Macromolecules 2006, 39, 2764.
- (3) Prokhorova, S. A.; Kopyshv, A.; Ramakrishnan, A.; Zhang, H.; Rühle, J. Nanotechnology 2003, 14, 1098.
- (4) Santer, S.; Rühle, J. Polymer 2004, 45, 8279.

J. Weinberg, R. Förch, K. Bender

Biofunctionalization of aminogroup-presenting plasma-polymerized thin films by covalent attachment of antibodies

Thin films exposing aminogroups at their surface often are used as substrates for reactions in a sense of biofunctionalization and therefore are a common part of general biosensor-concepts.

In this work, we investigated a method usually used for enzyme-modifications of antibodies for its possible useability to covalently bind antibodies to amino-group presenting plasma-polymerized films.

The attachment of biotinylated antibodies was observed by surface plasmon enhanced fluorescence spectroscopy (SPFS) by the use of labelled streptavidin as a detecting reagent.

The reductive cleavage of antibodies and fragmentation of the heavy chains in combination with this method of attachment may lead to a high-density packing of these surfaces with Fab fragments without blocking a huge amount of the antigen-binding sites, thus leading to a high sensitive and consistent detecting-matrix for a biosensor application.

Christian Schlemmer, Svetlana Santer

MPPPF – Nanoparticles do the waltz

Alle meine Entchen
schwimmen auf dem See
schwimmen auf dem See
Köpfchen in das Wasser
Schwänzchen in die Höh'.

Robert F. Roskamp, Patrick W. Beines, Maria Gianneli, Ulrich Jonas, Georg Fytas, Wolfgang Knoll

Functional Smart Hydrogels

Hydrogels are used in a broad variety of applications in daily life. Furthermore, environmentally sensitive, "smart" hydrogels have enormous potential for future development. These crosslinked polymers are known to respond to changes in temperature, pH, pressure, as well as chemical and electrical stimuli and irradiation. From this responsive behaviour arises the possibility of application in many fields like drug delivery, tissue engineering, purification and implementation as actuators or biosensors [1,2,3,4]. The structural features and swelling properties of hydrogels, investigated by optical methods, like surface plasmon resonance (SPR) and optical waveguide mode spectroscopy (OWS) [5], and by atomic force microscopy (AFM) [5] will be presented. In addition, the study of dynamical characteristics, by fluorescence correlation spectroscopy (FCS) [6], evanescent wave light scattering (EWLS) and related techniques, like total internal reflection microscopy (TIRM), will be discussed. We will also refer to chemical functionalisation, achieved via introduction of

active ester groups, subsequent to polymerisation [6]. Such a chemical modification provides access to an even larger scope of applications.

- [1] Qui, Park, *Advanced Drug Delivery Reviews* 2001, 53(3), 321
[2] Hoffman et. al., *Sensors and Actuators A* 1999, 77(2), 139
[3] Zhang et. al., *Langmuir* 2004, 20(17), 7303
[4] Peppas et. al., *Advanced Materials* 2006, 18(11), 1345
[5] Beines et. al., *Langmuir* 2007, 23(4), 2231
[6] Gianneli et. al., *Macromolecules* 2007, submitted

Christian Dorrer, Oswald Prucker, Jürgen Rühle
Ultrahydrophobic surfaces with posts and polymers

A combination of silicon micromachining and photochemistry is used to generate micro- and nanorough surfaces with extreme wetting properties. On some of these surfaces, drops easily roll around (superhydrophobicity), while on others, drops are sucked into the surface structure (superwetting). Condensation experiments reveal that superhydrophobic post surfaces are in general not resistant to penetration by water, as drop formation may occur into metastable states. In contrast, nanorough "nanograss" surfaces are condensation-resistant. On these surfaces, drops spontaneously move as a result of coalescence events.

Matthias Junk, Uli Jonas
Structure and Structuring of Thermoreversible Hydrogelsystems

Different methods were evaluated to get a better insight into the structural behavior of photocrosslinked hydrogels. These examined systems are temperature-responsive, showing a collapse at around 30°C. Atomic force microscopy (AFM) was used to monitor the surface and to determine the phase transition. Continuous wave electron paramagnetic resonance (cw EPR) studies of in-situ UV radiated samples allow a better understanding of the crosslinking mechanism. Furthermore TEMPO based spin probes reveal a bimodal collapse behavior. Structuring of the hydrogel was done on the one hand by UV radiation using a 3-beam interferometer, on the other by spin-coating the uncrosslinked polymer into a photoresist pattern. The structured hydrogels were characterized by optical microscopy and AFM.

Abstracts - Posters

Annette Brunsen, Wolfgang Knoll
Responsive dextrane-based hydrogels for application in biosensors

Responsive hydrogels change their swelling state according to external stimuli like temperature, pH or pressure. The maximum swelling degree depends on the chemical composition and the crosslinking density. This knowledge is used to develop a responsive photocrosslinked dextrane-based hydrogel with specific biofunctionalization for application in biosensors.

Dextrane mainly consists of 1,6-linked glucose chains of varying lengths. By oxidizing the hydroxyl groups to carboxyl groups and activating them by active ester chemistry many different functional groups can be introduced subsequently into the dextrane.

Thin films of the modified dextrans are produced by spin coating on gold surfaces coated with a self assembled monolayer of 11-mercapto-1-undecanol and S-3-(4-benzophenoxy)propyl ethanthioate.

Surface plasmon resonance and optical waveguide mode spectroscopy will be performed to investigate the behaviour of the synthesized hydrogels.

Christian Ohm
Hydrogels as a water reservoir for tethered bilayer lipid membranes

Tethered bilayer lipid membranes (tBLM) are solid supported model membrane systems. They mimic several properties of a natural membrane, and provide at the same time a simple, versatile and stable platform for systematic investigations of membrane related processes. They can host membrane proteins and allows thus for their investigation. One can even envision the use of tBLMs in sensor applications. One drawback, however, is their instability in air. To overcome this problem, we investigate the coupling of a hydrogel to the membrane. By growing a hydrogel layer on top of the tBLMs, the latter are supported with a water reservoir and an interface to the surrounding gas room. Hydrogel layers can be placed on the membrane only by gravity or be covalently attached to them. The synthesis of these structures and their electrical and optical properties will be reported.

Hatice Duran, Uli Jonas, Wolfgang Knoll
Synthesis of Polypeptide nanotubes for biosensor applications

For abstract see talk.

M. Mir, R. Roskamp, B. Menges, W. Knoll
Oligonucleotide biofunctionalisation of smart hydrogels observed by surface plasmon fluorescence spectroscopy

The abundant amount of information contributed by the Human Genome Project has conferred to DNA microarrays an increasing use in diagnostic, which allows the analysis of a wide range of different diseases. This expression analysis requires accurate, sensitive and reproducible DNA chips that support quantitative determination. Most of the applications require high sensitivity, which has promoted the study of signal amplification techniques.

Hydrogels contributes to a large net surface to immobilise the bioreceptor on the sensor surface, thus higher amount of target can be attached with the subsequent increase of sensitivity. The hydrogel polymer used in this work is a N-isopropylacrylamide, methacrylic acid and 4-methacryloyloxy-benzophenone that confers smart behaviours to the sensor. The N-isopropylacrylamide changes the swelling state of the polymer modifying temperature, pH

or ionic strength. This behaviour allows an increase of the active surface of the sensor in the swelling state and a distance decrease of the reporting molecule to the sensor surface in the collapse state, improving their detection. Metacrylic acid confers a functional group to attach covalently amino labelled oligonucleotides and 4-methacryloyloxy-benzophenone group can be crosslinked by UV light, which allow the use of photolithography for the patterning of hydrogel nanostructures on an array format.

Omar Azzaroni

Doing Chemistry in Thin Polymer Films

The chemistry that occurs at interfaces plays a determinant role in our everyday life, ranging from biological to large-scale industrial processes. This can be observed when following the development of novel biosensors or efficient catalysts based on nanomaterials. During the last decades, surface science and materials engineering have made remarkable progress on the molecular design of interfaces. Most of this progress had been based on the modification of surfaces using thin polymer films. In recent years, research into surface modification has focused on the use of the so-called "polymer brushes". These particular macromolecular architectures are polymer chains tethered at one end to a solid substrate forming a brush-like layer of elongated coils. When dealing with polyelectrolyte brushes the conformation of the brush-like layer is dominated by electrostatic interactions between segments of like charges. Changes in ionic strength, pH and solvent properties lead to markedly different surface properties due to transitions in the polymer brush between stretched and collapsed states. In this presentation we will discuss the modification and control of surface properties of materials by means of charged polymer brushes. Moreover, we will describe the different options available for nanochemistry inside the surface-grafted macromolecular layers. Within this proposed framework we used polyelectrolyte brushes to switch wettability, to site-selectively deposit materials or to immobilize nanomaterials, just to name a few examples. These examples show that polymer brushes can be a valuable toolbox for surface chemists.

Julien Couet, Markus Biesalski

Synthesis of polymer-wrapped peptide nanotubes

For abstract see talk.

Yuri Egorov, Markus Biesalski

Crosslinked peptide nanotubes

The peptide - synthetic polymer nanotubes (PPNT) have possible application as materials for microsystem construction (e.g. nanofluidic, nanooptic) and as model systems for biomineralization and studying of biophysical phenomena. Our previous work deals with synthesis PPNT containing linear synthetic polymer chain (n-BA, Styrene), but during in-situ polymerization their stability is decreasing with growing of polymer chain length. In this work we use two approaches for the stabilization of PPNTs: the first is crosslinking using a bifunctional monomer - ethylenglycoldimethacrylate, the second is photochemical crosslinking using cyclic peptide with two benzophenone moieties.

Sidar Loschonsky, Markus Biesalski

Controlled polymerization from initiator-modified peptides

Peptides and/or amides that mimic the side chain of lysine were modified with ATRP initiators to perform peptide polymer hybrid materials with structural and bioactive motifs. The influence of the chemistry of the initiator, the temperature, and the solvent concentration on the kinetics of the reactions were studied with respect to the evolution of molar mass, polydispersity, and initiator efficiency.

Sönke Petersen, Markus Biesalski

Peptide polymers on microstructured surfaces

A strategy to immobilize peptide-polymer hybrids for the design of live-cell arrays is presented. A GRGDSP-Peptide modified with an ATRP initiator is used to synthesize a peptide-polymer hybrid that is attached to a surface and there stabilized by photochemistry. First studies on cell adhesion on these surfaces include a surface characterisation and the evaluation of the influence of the peptide concentration in the attached film. Photolithography is used to create microstructured surfaces needed for live-cell arrays.

Kimberley Simancas, Oswald Prucker, Jürgen Rühle

Swelling behavior of surface-attached strong polyelectrolyte - surfactant complexes

The study of surface-attached strong polyelectrolyte-surfactant complexes is proposed based on the swelling behavior of strong polyelectrolyte brushes in salted solutions and experimental results on weak polyelectrolyte-surfactant complexes. For this purpose, interactions between MePVP brushes and sulfonate and carbonate soaps will be studied by means of spectroscopic ellipsometry and FTIR.

Ding-Ding He, Oswald Prucker, Jürgen Rühle

Fishing in a Beaker: Vitamin D capturing with hydrogels

A hydrogel is a network of polymer chains that are water-insoluble. New synthesized hydrogels with hydrophobic pockets absorb more Methnal than water. With adjusting of the polarities of the solution, the swelling behavior and the hydrophobic-hydrophilic balance of these gels can be alternated greatly. The controlled capturing and releasing can be realized under these conditions.

Christine Schlipf, Kerstin Schuh, Oswald Prucker, Jürgen Rühle

Novel Polyelectrolyte Gels for Biofuel Cells

In this project, we work on the development of new materials with tailor-made properties for biofuel cells. This includes on the one hand the synthesis and characterization of polymeric networks as cell-matrix. So far, we have developed a new thermal crosslinker which can be incorporated into common polymers and crosslinked in a controllable way. On the other hand, attention will be directed to the integration of (bio)catalyst into the polymer matrix and the realization of efficient electron transport between catalyst and electrode surface.

Nicolas Schorr, Oswald Prucker, Jürgen Rühle

Towards polymer based magnetic microstructures

Miniaturization of lab-on-a-chip diagnostics is limited by the means of mixing and propulsion of fluids on the micro litre scale. Nature provides an efficient solution: small asymmetrical moved cell projections, called ciliae, can be found in many organisms. Here, several approaches to realise a nature inspired replication made from polymer/magnetite composites are investigated.

G.K. Raghuraman, Oswald Prucker, Jürgen Rühle

A novel approach to attach polymer monolayers and its use for premolded packages

In this work, we are going to describe how azides can be useful in attaching polymer monolayers on various surfaces. The substrate of interest was immobilized with silanes or phosphonic acid end groups with long chain alkyl derivatives on the other end. Then α -azido polystyrene (or) 4-sulphonylazidopolystyrene was spin-casted and then the polymer groups were attached to the surface by thermal treatment. Using this method, it is also possible to design premolded packages of interest.

Thomas Brefka, Thomas Brandstetter, Jürgen Rühle

Microarray read-out technology using attenuated total internal reflection

For a simple usable and cheap microarray production and read-out technology, we developed a system using fluorescence excitation for an evanescent field. Thereby, light is coupled into the substrate. Setting the couple angle to the value from which on attenuated total reflection appears leading thus to the substrate serving as a waveguide. An evanescent wave travels along the surface exciting bonded analyte molecules, but does not lead to fluorescence of analyte molecules in solution. The intensity of the fluorescence light is detected by a CCD-camera. The analyte solution is temperature controlled in a flow cell. Experiments showed the ability of our system to measure low concentrations of analyte molecules. Furthermore we investigated the systems performance. Our new 3D microarray technology offers a leap in detection efficiency. The comparison between today's standard glass and the used plastic substrate evinces a nearly same behavior. This technology can even be established in medical applications like the detection of gene mutations (SNPs).

Gerhard Baaken, Markus Sondermann, Oswald Prucker, Jan Behrends, Jürgen Rühle

A 42-type planar patch clamp chip

For abstract see talk.

Meike Moschallski, Oswald Prucker, Jürgen Rühle

Antibody Microarrays Based on Microstructured Surface-Attached Hydrogels

All polymer protein chips based on surface-attached hydrogels show higher fluorescence signals in immunoassays than standard antibody monolayers on silanized glass slides. The immunoassay kinetics are analyzed using the ATR-reader. From these the concentration of specific analyte proteins in solution can be measured.